Lab 4 Report

ECE 332 Winter 2020

Jose Manuel Lopez Alcala & Benjamin Carlson

1 Introduction

In this lab, our aim was to be able to control a three-phase ac induction motor using variable frequency sinusoidal PWM signals. Each phase of the motor was to be connected using a driver board and establishing a reference frequency that represents the frequency of the sinusoid. This reference frequency was then implemented by generating a switching PWM frequency of 1000Hz. Our focus was on making a program that would be able to change the reference frequency of the sine waves and therefore the speed of the motor.

2 Methods

2.1 Hardware

The hardware was connected identically as in the last lab. Figure 1 shows the board to which we connected the motor to.

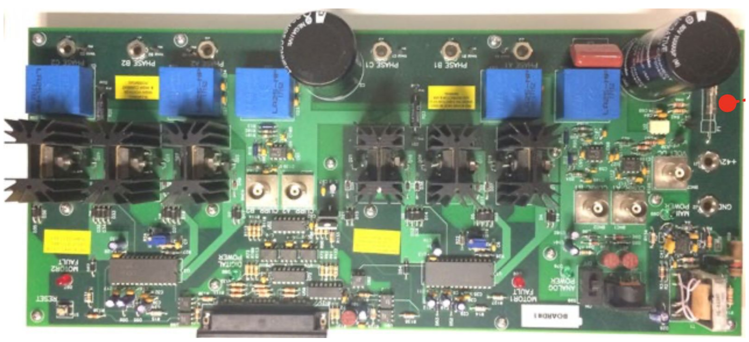

Figure 1. Controlling board for motor

The board was connected to the power supply that supplied the motor power. Additionally, it had another power supply that powered the logic on the board itself. This power supply is shown in Figure 2.

Figure 2. Power supply for logic on controlling board.

The three-phase ac induction motor was powered by 42 VDC from the power supply through an active bridge inverter in the board and output a three phase sinusoidal PWM signal to create the rotating magnetic field required to control the speed of the motor.

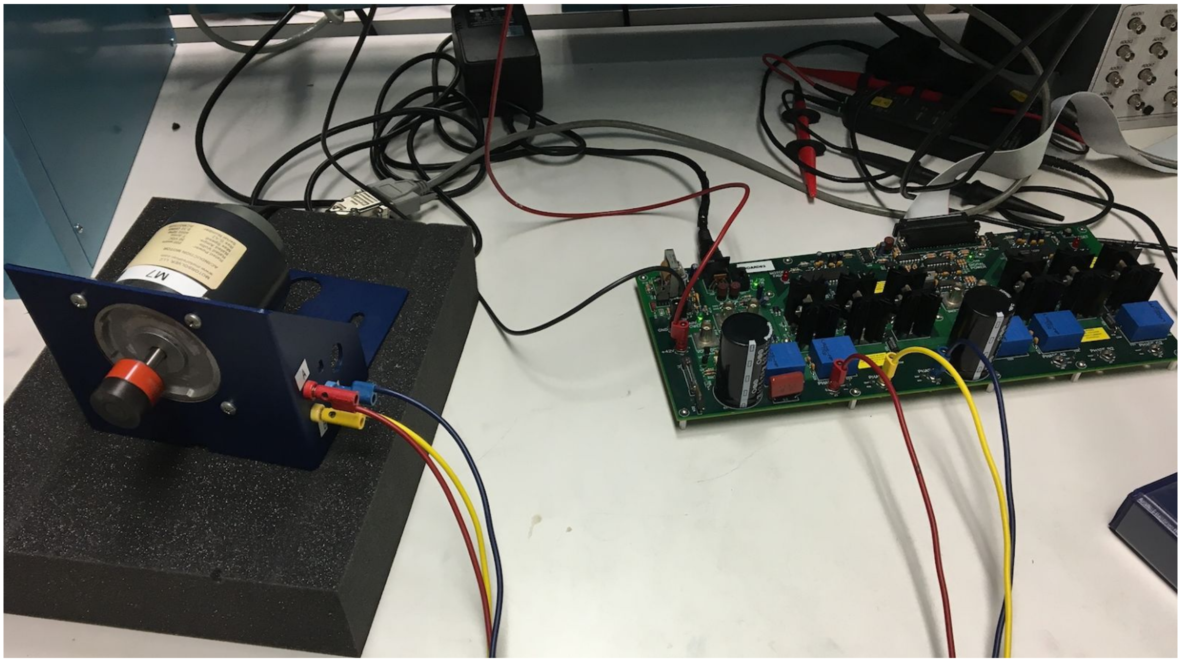

Figure 3. Experimental set-up.

2.2 Programming

For this lab, we reused code from Lab 3. More specifically, we reused the averaging block. This system's main goal is to return the average RPM and the displacement of the motor. We are only really interested in the RPM. An image of this design can be seen in Figure 3.

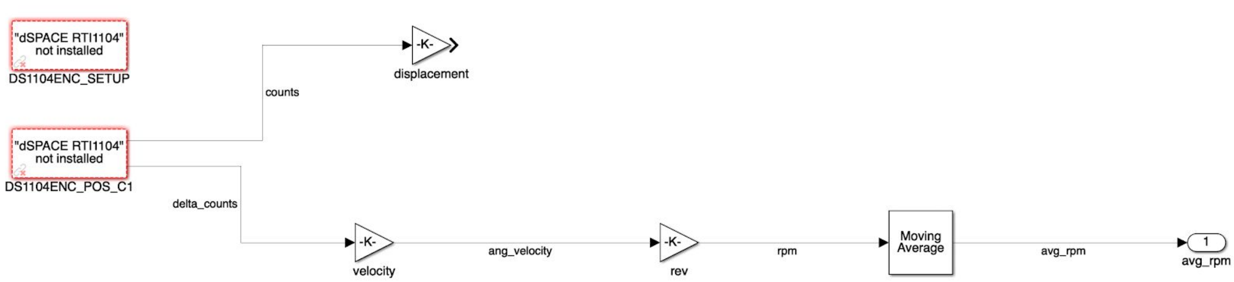

Figure 4. Averaging block that returns average RPM and displacement of the motor.

In addition to this code, we design the variable frequency block. This design's main focus is to be able to take an input, the frequency constant, and update the controlling wave that is being fed into the three separate PWM signals being sent to each phase of the motor A, B, and C. The resulting design can be viewed in Figure 4.

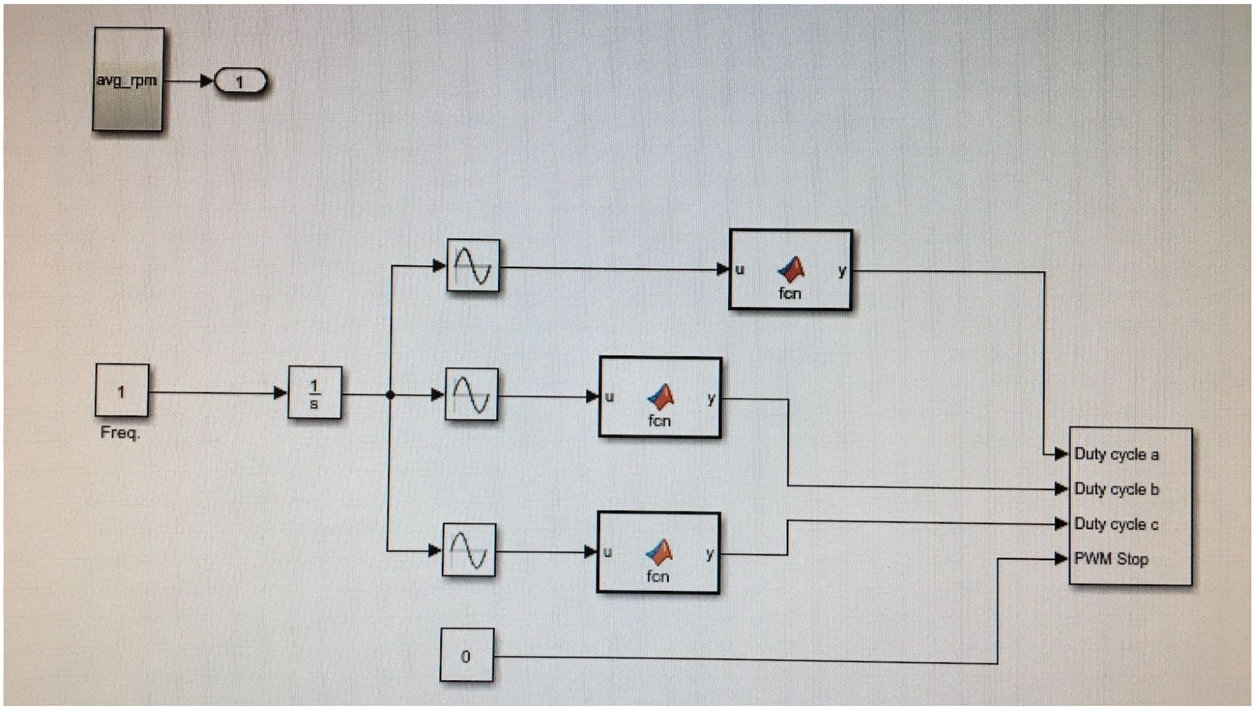

Figure 5. The variable-frequency design that controls the motor speed. This was implemented Simulink.

When changing the frequency value, the input gets integrated and multiplied by the argument of each of the three sine waves, as seen in figure 5. The signal then gets fed into a function that shifts the value of the bounds between zero and one. This bounding makes sure that the phase controller receives a valid positive input that can be represented by a PWM signal and doesn't include negative values. The fcn blocks' code that bounds the output is shown in figure 6.

```
function y = fcn(u)

u = u+0.5;
if u >= 1
    u = 0.999;
elseif u <= 0
    u = 0.001;
else
    u=u;
end
y = u;
end
```
Figure 6. Matlab code that bounds the output to the phase controller

3 Results

The design was synthesized and uploaded to the hardware without any problems. The system worked as expected with a single slider input controlling the speed of the motor. A GUI was created in dSpace using their software and we were able to graph out the average RPM and have a slider with which we controlled the reference frequency of the sinusoidal input voltage that controlled the speed at which the motor rotated. Figure 7 shows an example of the output of as seen from dSpace.

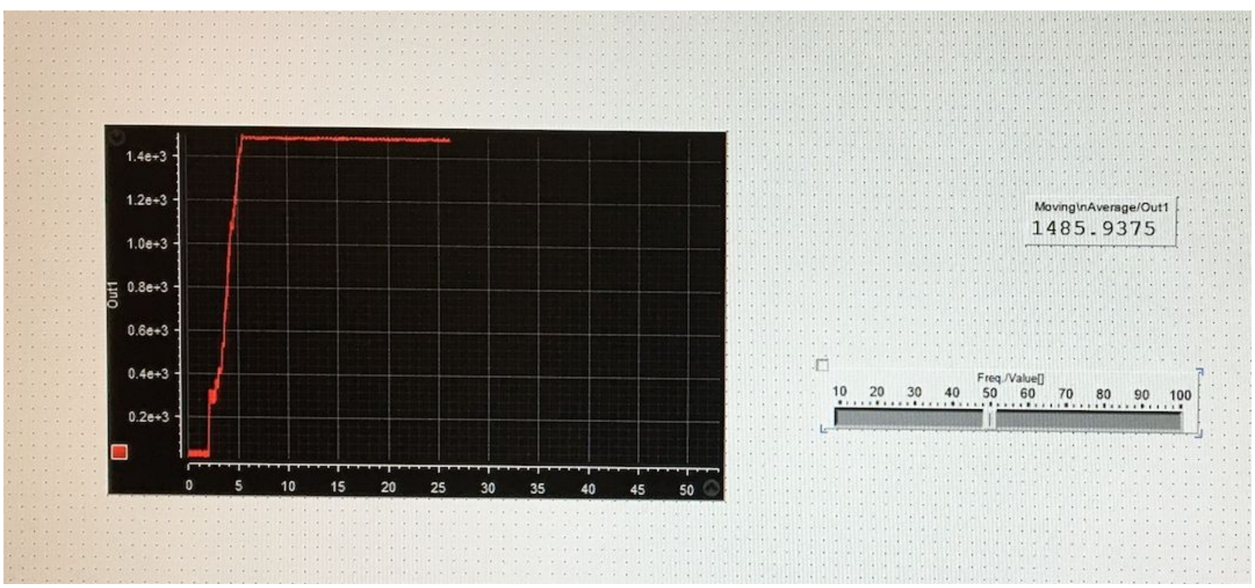

Figure 7. The graphed output, on dSpace, of the RPM and slider that controlled the frequency value.

The resulting motor was reacted very quickly to changes in user input with an output RPM displayed by the system being in agreement with our theoretical calculations, with a margin of error of less than 1% while operating at 50Hz.

4 Discussion

For this lab, the result of our design and implementation resulted in an open-loop controlled system with variable frequency. The behavior of the motor was similar to the dc open-loop control we designed in lab one, but with distinct differences. The most notable being the physical construction of the motor and the three-phase ac operating principles. Secondly, the ac motor was much more reactive than the previous design. This design will be built upon in Lab 5 and expanded to create a closed loop system much like the DC motor from Lab 3.